BLM3051 - Data Communication
Lecture Notes

Şafak Bilici

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What Is Communication?

- Sharing information - data.
- Telecommunication [1]
- Communication aim: traffic data.
- Telephone, television, etc.
    - Audio, video, image
- Computer
    - Medium (singular)/Media (plural) → 0/1
- Protocol Stack: Software and Hardware

Essentials of Data Communication

- Message
- Sender
- Reciever
- Medium
- Protocol

Data Communication Features

- Delivery
- Accuracy
- Timeliness

Pros Of Computer Network

- Resource Sharing
- Info/Data Sharing
- Load Sharing/Balancing
- Reliability
- Economy
- Efficient communication between in different places.

[1] tele: Greek → far

Evaluation Criteria For Computer Networks

- Performance
  - Transmit time
  - Response time
- QoS
  - Circuit-switched (Synchronous)
    - bit rate, min error rate, transmission rate
  - Packet-Switched (Asynchronous)
    - Max packet size, mean packet transfer rate, mean packet error rate, jitter, mean packet transmit delay
- Reliability / Availability
  - MTBF - Mean Time Between Failure
  - Restoring time
  - 5-9 $\rightarrow$ 99,999%
- Security
- Scaleable
- Adaptable

Network Standards

- De Jure
  - De jure standards, or standards according to law, are endorsed by a formal standards organization. The organization ratifies each standard through its official procedures and gives the standard its stamp of approval.
  - ISO (International Organization For Standardization
  - ITU, IEEE, ETSI, TIA, ANSI, TSE, IETF
- De Facto
  - De facto standards, or standards in actuality, are adopted widely by an industry and its customers. They are also known as market-driven standards. These standards arise when a critical mass simply likes them well enough to collectively use them. Market-driven standards can become de jure standards if they are approved through a formal standards organization.
  - QWERTY Keyboards, VHS Video Format, PDF document types, buttons on men's shirts are on the right and buttons on women's shirst are on the left, etc.

Computer Network (CN)

- ARPANET (1970s)
- Classification of Computer Networks
  - Technique of Transmission
    - Broadcast (Television)
    - Peer to peer - P2P (machine w machine)

- Multicast (twitch)
- Network Dimension
  - PAN - Personal Area Network (<10 m)
  - LAN - Local Area Network (< 100 m - 200 m)
  - CAN - Campus Area Network (<1 - 5 km)
  - MAN - Metropolitan Area Network (< 10 - 50 km)
  - RAN - Regional Area Network (< 100 - 200 km)
  - WAN - Wide Area Network (< 1000 km)
- Bit Rate

Topology

Bus Topology

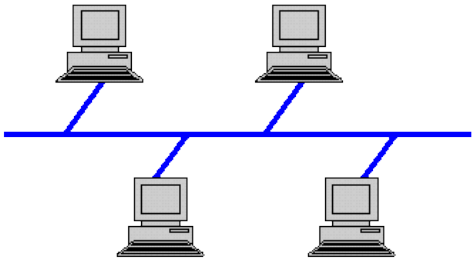

Figure 1: Bus Topology

A bus topology is a topology for a Local Area Network (LAN) in which all the nodes are connected to a single cable. The cable to which the nodes connect is called a "backbone". If the backbone is broken, the entire segment fails. Bus topologies are relatively easy to install and don't require much cabling compared to the alternatives.

It transmits data only in one direction and every device is connected to a single cable. The advantages are: it is cost effective, cable required is least compared to other network topology, used in small networks, easy to expand joining two cables together. The disadvantages are: cables fails then whole network fails, if network traffic is heavy or nodes are more the performance of the network decreases, cable has a limited length, it is slower than the ring topology.

Star Topology

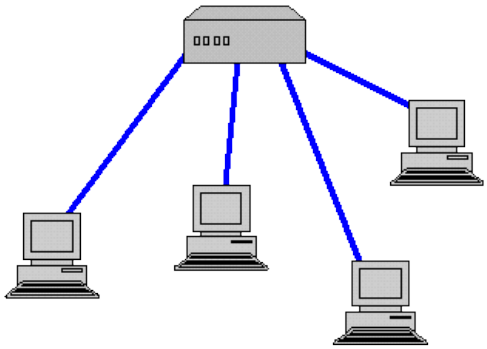

Figure 2: Star Topology

A star topology is a topology for a Local Area Network (LAN) in which all nodes are individually connected to a central connection point, like a hub or a switch. A star takes more cable than e.g. a bus, but the benefit is that if a cable fails, only one node will be brought down. All traffic emanates from the hub of the star. The central site is in control of all the nodes attached to it. The central hub is usually a fast, self contained computer and is responsible for routing all traffic to other nodes. The main advantages of a star network is that one malfunctioning node does not affect the rest of the network. However this type of network can be prone to bottleneck and failure problems at the central site.

Every node has its own dedicated connection to the hub and hub acts as a repeater for data flow. Advantages are: Fast performance with few nodes and low network traffic, hub can be upgraded easily, only that node is affected which has failed, rest of the nodes can work smoothly. Disadvantages are: cost of installation is high, if the hub fails then the whole network is stopped because all the nodes depend on the hub, Pprformance is based on the hub that is it depends on its capacity.

Ring Topology

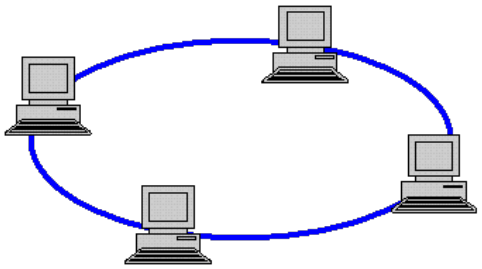

Figure 3: Ring Topology

A ring topology is a topology for a Local Area Network (LAN) in which every device has exactly two neighbours for communication purposes. Typically, all messages travel through a ring in the same direction. A failure in any cable or device breaks the loop and will take down the entire segment. Another disadvantage of the ring is that if any device is added to or removed from the ring, the ring is broken and the segment fails.

A number of repeaters are used for Ring topology with large number of nodes, because if someone wants to send some data to the last node in the ring topology with 100 nodes, then the data will have to pass through 99 nodes to reach the 100th node. Hence to prevent data loss repeaters are used in the network. The transmission is unidirectional, but it can be made bidirectional by having 2 connections between each Network Node, it is called Dual Ring Topology. Advantages are: transmitting network is not affected by high traffic or by adding more nodes, as only the nodes having tokens can transmit data, cheap to install and expand. Disadvantages are: troubleshooting is difficult in ring topology, adding or deleting the computers disturbs the network activity, failure of one computer disturbs the whole network.

Tree Topology

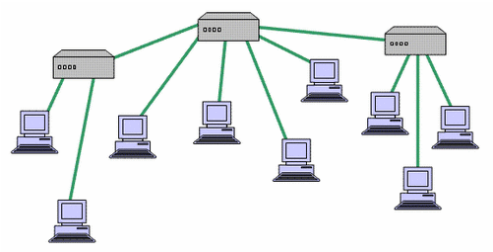

Figure 4: Tree Topology

It has a root node and all other nodes are connected to it forming a hierarchy. It is also called hierarchical topology. It should at least have three levels to the hierarchy. Ideal if workstations are located in groups and Used in Wide Area Network. Advantages are: extension of bus and star topologies, expansion of nodes is possible and easy. Disadvantages: heavily cabled, if more nodes are added maintenance is difficult, central hub fails, network fails.

Mesh Topology

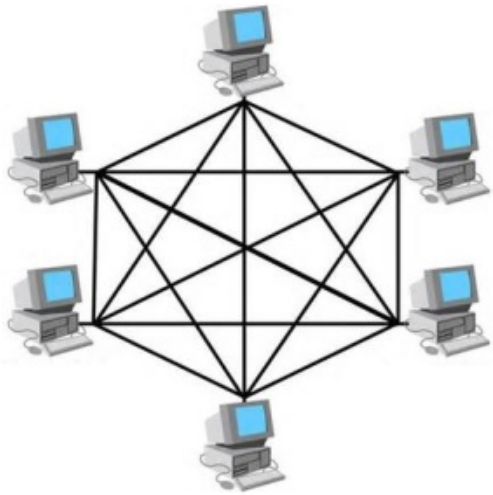

Figure 5: Mesh Topology

It is a point-to-point connection to other nodes or devices. All the network nodes are connected to each other. Mesh topology is fully connected, robust and not flexible. Advantages are: each connection can carry its own data load, provides security and privacy. Disadvantages are: installation and configuration is difficult, cabling cost is more.

Hybrid Topology

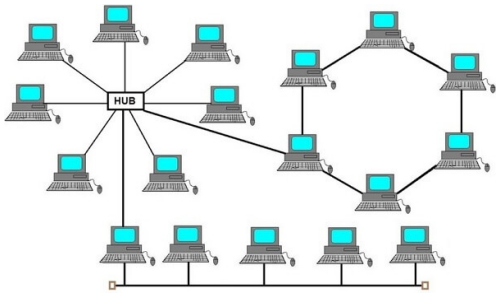

Figure 6: Hybrid Topology

It is two different types of topologies which is a mixture of two or more topologies. For example if in an office in one department ring topology is used and in another star topology is used, connecting these topologies will result in Hybrid Topology (ring topology and star topology). It is a combination of two or topologies and inherits the advantages and disadvantages of the topologies included. Advantages are: reliable as error detecting and trouble shooting is easy. Disadvantages are: complex in design and costly.

Transmission Model

- Simplex: Uni-directional P2P
  - Mouse
  - Barcode reader
- Half-Duplex
  - Radio

Adressing Model

- Broadcast
  - TV
- Multicast
- Anycast
- Unicast

Data Flow Density, Bitrate, Throughput

- Symmetric
- Assymetric
- bps (bit-ps), Bps (byte-ps)
- Throughput

- Response time
- Jitter

WEEK 2

OSI Reference Model

- ISO - 1984
- De Jure
- Features
    - All layers are open
    - Flexible
    - Robust
    - Interoperable
    - Easy to explain
    - 7-layers
    - Never applied / ideal model

Layers In OSI

1. Physical Layer
2. Data Link Layer
3. Network Layer
4. Transport Layer
5. Session Layer
6. Presentation Layer
7. Application Layer

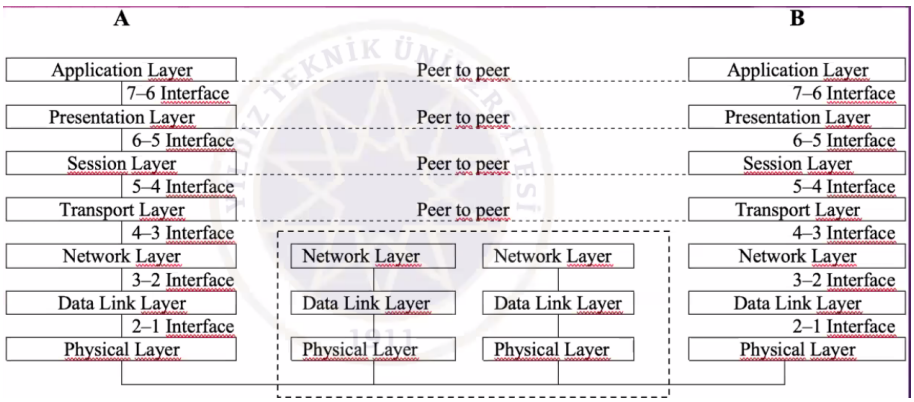

Figure 7: OSI Layers

- Each layers add a header package.
- Only second layer (Data link) add a trailer package.
    - Error Control
- Encapsulation

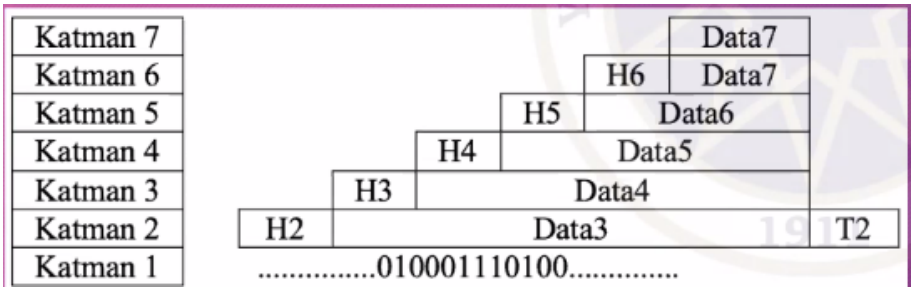

Figure 8: OSI Layers

OSI - Physical Layer

- Cable or noncable
- Responsible for trasmitting bit arrays between peers
- General functions of the Physical Layer:
  - Electromechanic
  - Direction of the package
  - Determining magnitudes of signals
    - Amplitude, Wavelenght, Frequency
  - Initiation and termination of the physical connection.

OSI - Data Link Layer

- Extract/divide frames from the message
- Top layers cannot process big amount of data, so we need to divide frame by frame our data.
- Using acknowledgment (ACK) info;
  - In case of an error
  - In case of not receive the package
  - Re-transmission
- Add header and trailer data to frames.
  - To determine the starting and ending points of the frame
- Header includes:
  - Sender address
  - Receiver adress
  - Order info
- Trailer includes:
  - A code (to check errors)
- To sum up, general functions of the Data Link Layer:
  - Node to node error free delivery
  - Addressing (in header part)
    - MAC Address
  - Access Control

    - Flow Control
    - Error Handling.
    - Synchronization
- In Local Area Network (LAN)
    - DLL divides into 2 different layers
        - LLC (Local Link Control)
        - MAC (Media Access Control)
- Communication at the data link layer is in the same network

OSI - Network Layer

- Network layer şs responsible for
    - Efficient and accurately forwardşng the packet
    - From source to destination over different network links
- Communication at the network layer is in the different network.
    - Router (3rd level devices)
- Switching
    - Connection oriented
        - like telephone infrastructure system
- Routing
    - Determining the path between sender and receiver
    - Connectionless
        - Delivering packages
    - In DLL, data transfer occurs between nodes
- Address must be different from DLL's addresses.
    - Logical addresses
- Data transfer occurs between the source and the destination.
- To sum up, general functions of the network layer:
    - Source to Destination packet delivery
    - Logical addressing
    - Routing
    - Address transformation
        - Between logical and physical addresses
    - Multiplexing
        - Multiple physical connections on a single network connection at the same time.

OSI - Transport Layer

- Responsible for the transmission of data
  - from source to destination
- Network layer responsible for delivering data
- Transport layer responsible for delivering packages
  - data = package [ ]
- Data transmission is between applications, not computers.
- An additional addressing mechanism is required
  - to distinguish the applications form each other
  - Service Access Point - SAP
    - Ports
    - Sockets
- Transport layer divides incoming information into pieces (segment) in sizes supported by the infrastructure
  - Segmentation
    - Sequence number
    - Re-assembly
- There are two types of services
  - Connectionless
    - like post services
  - Connection oriented
    - Like phone services
      - Establish connection
      - Data transmission
      - terminate connection
    - More control over the data to be transferred
- To sum up, general functions of the Transport Layer:
  - Data transmission between source and destination nodes
  - to provide data flow between applications with the help of service points
  - segmentation and re-assembling
  - ensuring connection control
    - connectionless — connection oriented

OSI - Session Layer

- This layer is responsible for ensuring continuity.
  - Synchronization
- Decision mechanism
- Choosing connection type
  - Half-duplex
  - duplex

- Session data transfering
    - Password
    - Logon verification
- Sessions can be split into sub-sessions to ensure the reliability of the connection
- To sum up, general functions of the Session Layer:
    - Managing the session
    - Communication control
        - if it is half-duplex
    - Ensuring synchronization
    - Gracefull close

OSI - Presentation Layer

- General functions of the Presentation Layer:
    - Provides interoperability by eliminating possible differences in information representation between devices dyuring data communication
        - Abstract data syntax
    - Encryption and Decryption
    - Compression and Decompression
- User interfaces
    - Electronical mail
    - File transfering
    - Remote desktop
    - Internet explorer
    - etc.

WEEK 3

Signals

There are two types of signals. Analog (continious) and digital (discrite). Both analog or digital, signals can be classified as periodic or non-periodic.

Analog Signals

A simple analog signal defined as

$$f(t) = A\sin(2\pi ft + \theta)$$

and complex analogue signal is defined as

$$f(t) = \sum_{n=1,3,5}^{\infty} \frac{1}{n}\sin(2\pi nft)$$

- v - Amplitude
    - Volt -v
    - Amper - A
    - Watt - W
- f -Frequency
    - Cycle
    - Hertz - hz
- phase
    - degree
    - radian - π

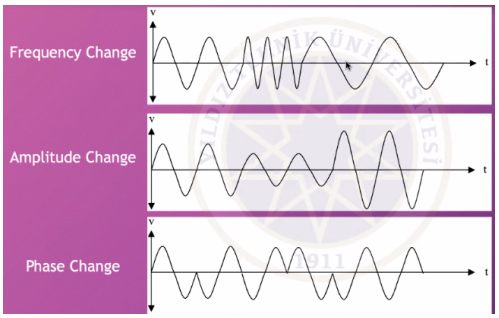

Figure 9

Digital Signals

- Non-periodic
- Bit-rate
    - the number of bits transferred in one second.
- Bit-interval
    - the time it takes to transmit one bit (in seconds)

Elements That Negatively Affect Communication

- Distortion
    - Attenuation
        - dB
        - Solutiin: Amplifying
            - Analog?
            - when analog signal is amplified, also the noise is amplified.
    - Noise
        - Even idle mode
        - Thermal noise
            - motion of atomic fragments
        - Impulse noise
            - Random electromagnetic signal
    - Cross talk
    - Delay
    - Propogation: Velocity of a sinusodial signal in a transmission line.

Data Carrying Capacity

-
  - The amount of data can be sent per unit time
  - H: Band width
  - V: Number of discrete voltages
  - $data_{vel} = 2H \log_2 V \ bit/sec$
  - Not consider the noise
- Noise (dB)
  - Signal Strength (sent): S
  - Stength of the current noise: N
  - $SNR = 10 \log_{10} \frac{S}{N} \ dB$
- Shannon-Hartley
  - Data velocity with noise
  - $data_{vel} = H \log_2 2(1 + \frac{S}{N}) \ bit/sec$
- First, the highest data rate to be achived is found according to the shannon-hartley formula.
-

Example: Since it is known that SNR vale on a transmission channel between 3KHz - 4KHz is 24dB, what is the maximum rate that can be obtained and the number of discrete levels that can be used for transmission?

$$SNR = 10 \log_{10} \frac{S}{N} \ dB$$
$$= 24 \ dB$$
$$\log_{10} \frac{S}{N} = 2.4$$
$$\frac{S}{N}$$
$$= 10^{2.4}$$
$$data_{vel} = H \log_2(1 + \frac{S}{N}) \ bit/sec \rightarrow H.log_2 10^{2.4} \approx H \times 8$$
$$data_{vel} = 8H \ bps$$
$$data_{vel} = 2H \ \log_2 V$$
$$= 8H$$
$$\log_2 V = 4$$
$$V = 16$$

Coding of Signals

- Digital - Digital
  - computer - printer
- Analog - Digital
  - Microphone - Computer
- Dİgital - Analog
  - Computer - Communication Lines
- Analog - Analog
  - Radio - Radio Signal Lines

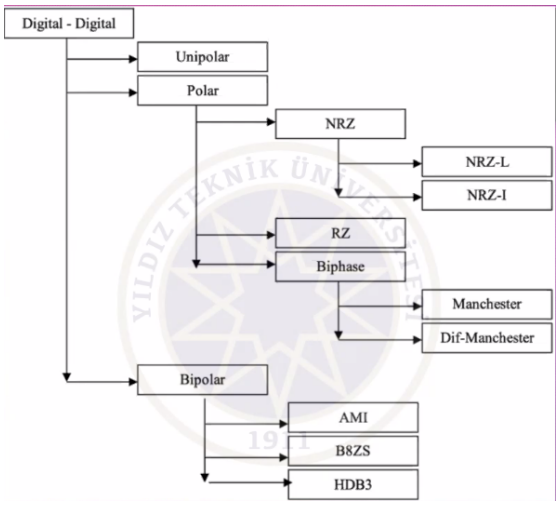

Figure 10

Digital2Digital - Polar Coding

- 3 main types
  - Non Return to Zero (NRZ)
    - Non Return to Zero-Level (NRZ-L)
    - Non Return to Zero-Inverted (NRZ-I)
  - Return to Zero (RZ)
  - Biphase
    - Best Digital2Digital Technique
    - Manchester
    - Differential Manchester

Digital2Digital - Bipolar Coding

- 3 Voltage levels
  - (+,- and 0) like RZ
  - 0V $\rightarrow$ 0
  - +,- $\rightarrow$

- AMI (Alternate Mark Inversion)
- B8ZS (Bipolar 8 zero Synchronizing)
- HDB3 (High Density Bipolar 3)

Analog2Digital

- PAM (Pulse Amplitude Modulation)
- PCM (Pulse Code Modulation)
- Nyquist Theorem
  - Sampling at least twice the highest frequency component is required

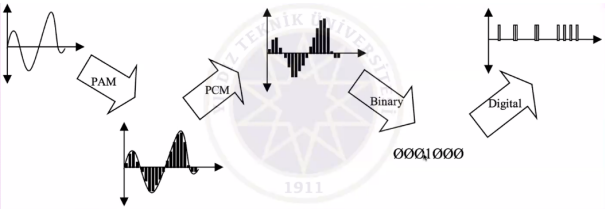

Figure 11

Digital2Analog

- ASK (Amplitude Shift Keying)
- FSK (Frequenct Sgift Keying)
- PSK (Phase Shift Keying)
  - It is not affected by voltage additions caused by external enviroment effects such as ASK, and bandwith related problems such as FSK.
- QAM

Analog2Analog

- AM (Amplitude Modulaton)
- FM (Frequency Modulation)
- PM (Phase Modulation)